Root respiration interferes with peat CO_2 emission measurement

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Abstract
Root respiration and microbial decomposition release CO_2 from peatland. Mixture between these two measurements causes an over-estimation of greenhouse gas contribution, because CO_2 produced by the former is offset by atmospheric CO_2 removal during photosynthesis. We separated the two components by measuring, from closed chambers, the CO_2 emission from the rooted (R) and non-rooted (NR) zones of peatland planted to oil palm. Three pieces of roots were channelled through a 5 cm hole into each of the grounded part of the R chamber. Emitted CO_2 was captured by 30-cm diameter and 30-cm tall PVC gas chambers, sampled using 10 ml syringes, and measured using gas chromatography. The measurements were conducted in Aceh, Sumatra in the early rainy season (Oct-Nov 2008). We found that CO_2 emitted from the NR chambers was about 62% of that of the R chamber, indicating a significant contribution of the root in producing CO_2. The average amount of emitted CO_2 from these 1, 5 and 10 year oil palm soils ranged from 18 to 24 t/ha/yr. Capturing both the R and NR zones in CO_2 emission measurement is advisable, but under limited resources, the NR zone should be prioritised.

Key Words
Peat, root respiration, microbial decomposition, CO_2 emissions

Introduction
Gas capture from closed chambers is one of the most common techniques in green house gas emission studies. CO_2 flux from peat soil as measured from the closed chamber is produced by both heterotrophic (microbial) and autotrophic (root) respiration. While the former component is related to peat decomposition and thus a net CO_2 emission, the latter is a near carbon neutral process; i.e. CO_2 is removed from the atmosphere though photosynthesis and perhaps lesser amount of CO_2 is released from root respiration. As such, measured CO_2 emission from the soil could be over-estimated if these two components are not separated. This research was aimed at assessing the effect of the rhizosphere on CO_2 emissions. The level of root respiration influence can be used to correct the figure of peat decomposition related oxidation.

Methods
This research was conducted in the peat domes in three villages of Aceh Barat District, Nanggroe Aceh Darussalam (NAD) Province of Indonesia in Nov. to Oct. 2008. The emitted CO_2 gas was captured using closed chambers from the rooted (R) and non-rooted (NR) chambers or zones.
The observation was conducted at smallholder oil palm plantations with 10, 5, and 1 year old plant stands. For each of the age group five pairs of observation points were made; each with R and NR treatment. The observation points of the five pair transect were arranged at 10, 55, 100, 145 and 190 m perpendicular to the drainage canal. The drainage canal where the measurement were taken, varied in depth between 1.5 m to 0.7 m depending on the position of observation points relative to tertiary canal or shallower field canal. As the water table level in the canal fluctuates in the canal as well as measurement points, water table depth was measured using a measuring stick from auger hole as deep as 1 m at the midpoint between the R and NR. The closed chambers of 30 cm diameter and 30 cm tall were made of PVC tubes. The bottom brim of the chamber was sharpened to minimize soil compaction during their insertion into the ground.
For each chamber designed for rooted zone emission, a hole of 5 cm diameter at a point 20 cm from its top was made for channelling three pieces of oil palm roots in such a way that the roots can still grow and develop inside the chambers. These chambers were installed at a distance of 2.5 m, 1 m and <1 m from the trunk of oil palm aged 10 years, 5 years and 1 year, respectively according to the distribution of the plant roots. The paired R and NR chambers were mounted at a distance of 1 m from each other.
Each chamber was equipped with a septum to place the needle puncture. A small (6 cm battery powered) fan was installed inside the chambers to stir the gas. A thermometer was also installed for each chamber to measure the temperature during the gas sampling.

Gas samples were taken by using syringes 10 ml capacity, with a sampling frequency of 0, 5, 10, 15, 25 and 35 minutes after closing of the chambers. Sampling was conducted at 07:00 to 10:00 a.m. and emission during this time range is assumed to represent the emission during the 24 hours. Samples were analyzed within 24 hours after sampling using a portable gas chromatography. The difference between R and NR treatments were tested using the t-test pair-wise comparison.

Results

The pair-wise comparison test shows that CO_2 emission from the rhizosphere zone is significantly higher than that of non rhizosphere ($p = 0.000$; Table 1). Under this experiment condition the non-rhizosphere CO_2 emission was about 62% of that of the rhizosphere one. This means that the measurement of CO_2 emission made on the rhizosphere zone overestimates the assessment of CO_2 emission, because the root respiration does not contribute to the net CO_2 emission as it is offset by CO_2 removal during photosynthesis. Where the NR data are available, they are more reliable for the reflection of peat decomposition in the green house gas studies. Our data of non rhizosphere emissions, with mean values ranging from 18 to 24 t CO_2/ha/yr are less than half than the predicted values of Hooijer *et al*. (2006) of around 54 t CO_2/ha/yr under the drainage depth (in this case, the water table) of around 60 cm, Melling *et al*. (2005) of around 50 t CO_2/ha/yr for oil palm in Sarawak Malaysia and Jauhiainen *et al*. (2001) for stabilized agriculture on peatland.

For each age group, CO_2 emission under the R zone is consistently higher than the NR zone, although for the 1-year age group the p-value is rather high ($p>0.20$). This is presumably because of the limited measurements for this age group. The amount of CO_2 emission from the 1-year old oil palm is higher than that of the older palm (Table 1), and Jauhiainen (2001) attributed this to the relatively higher content of raw organic matter that are more readily decomposed as is the case in the young plantation relative to the older ones.

Table 1. Mean ± standard deviation and the t-test for pair-wise comparison between the non rhizosphere (NR) and the rhizosphere (R) treatments of CO_2 flux at different age of oil palm.

Age	NR	R	N	t-test
Year	t CO_2/ha/yr			
1	24.3 ± 9.7	40.9 ± 18.0	8	0.2109
5	18.2 ± 11.1	27.3 ± 15.6	27	0.0001
10	19.3 ± 16.6	32.9 ± 20.7	21	0.0020
Average	19.5 ± 13.2	31.3 ± 18.3	56	0

Hooijer *et al*. (2006), from a literature review, presented a positive linear correlation between CO_2 emission and water table depth. Likewise, our unpublished observation in West Kalimantan Province showed lower carbon stocks at points closer to the deep drainage canal, indicating a more rapid decomposition at these points were water contents are likely lower than those points further away from the canal.

In this current research, however, the effect of instantaneous water table depth on CO_2 emission was rather inconsistent (Figure 1). Jauhiainen *et al*. (2008) demonstrated that the highest rate of emissions were at points where water table depth is around 60 cm. When the water table depth is shallower, then the soil water content tended to be more saturated, whereas, when the water table is deeper, the soil water content is dry and thus less favourable for microbial activities.

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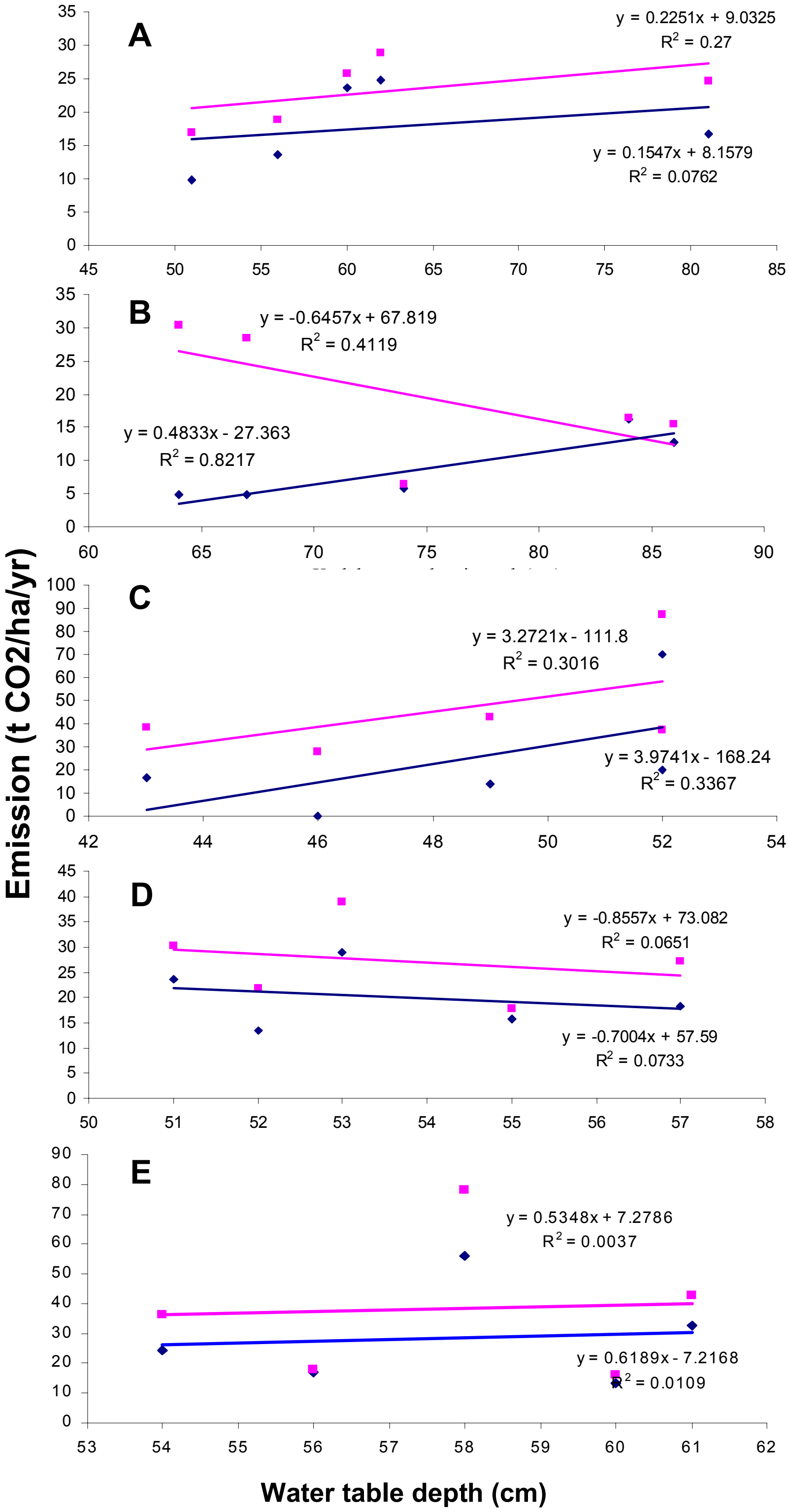

Figure 1. CO_2 flux under smallholder oil palm plantation in transects: A. Under 10 year palm stand, 1.5 m drainage depth; B. Under 10 year palm stand, 1.5 m drainage depth; C. Under 10 year palm stand, 0.7 m drainage depth; D. Under 5 year palm stand, 0.7 m drainage depth; E. Under 5 year palm stand, 0.7 m drainage depth. The red line is rooted and blue line is non-rooted zones.

Conclusions

Our research shows that it would cause a strong overestimate of peat soil contribution to CO_2 emission when the measurement is conducted in rooted area. Thus when zoning of the measurement is not possible, measurement should be conducted on relatively root free areas.

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